Georgian Technical University
(GTU)

GEOMETRY DESCRIPTION BASED ON CATIA CAD

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https://indico.cern.ch/event/1065545/

ITK Plenary, 08 March 2022

ITK Week 7 Mar 2022 – 11 Mar 2022

TAI Agreement with GTU

- Technical Associate Institute agreement with ATLAS started in 2022 and will follow up to 5 years
- WP04: Cross-checking of Materials Description in the PP1 Region

GTU Georgian Technical University

Expression of Interest
to
join the ATLAS Collaboration
as
Technical Associate Institute
4 September 2021

The Georgian Technical University (GTU) requests to join the ATLAS as a Technical Associate Institute for an initial period of *five* years. Within the ATLAS collaboration, GTU will contribute to ATLAS software developments.

1. Background

GTU in the center of Georgia's capital Tbilisi is the largest technical University in Georgia [1] having rich traditions of study and research in engineering disciplines from early in the XIX century. 10 faculties, 21 scientific centers, and 13 affiliated research institutes, 1'176 professors, 442 PhD, 927 doctorate students, 75 researchers are performing scientific-research activities in the field of – Information Technologies, Cybernetics, Metallurgy and Chemistry, Nanotechnologies, Biotechnologies, Machine Building, Aeronautics, Civil Engineering and Architect, Communications, Power Engineering, Transport, Mining, and Geology.

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at various levels of ATLAS meetings. The code will be developed and released in accordance with open-source policy of ATLAS collaboration software development. Other visualization projects like GeoModelExplorer, Phoenix will be able to profit from this study by means of the code, expertise, and know-how.

FTE assigned: 1.0
Duration: 2 years

WP04: ITK

Cross-checking of Materials Description in the PP1 Region

The PP1 region of ITk has a very complex geometry. It is essential to have accurate geometry descriptions in that region for precise simulation of the forward region performance. It is proposed to provide a cross-check of the actual ITk simulation geometry with an "as-build" CATIA CAD geometry. Given its complexity, the PP1 region is particularly interesting for this initial analysis. Differences may be discovered in weight, volume, positioning, geometry configurations, and radiation lengths. The CATIA descriptions will be developed starting from the Engineering Databases of ATLAS and comparison analyses will be carried out by the methods and tools developed by GTU in CATIA. The GTU group has developed a unique method that enables to calculation and check of the radiation length in CATIA using non-simplified as-built geometry descriptions. This tool enables to make estimations of geometries on the early stage of development and provide checks of the existing simulation geometries.

The team of Georgian Technical University already discussed possible outcomes for ITk on the ITk Offline SW meeting On 19 Feb 2021 [11]. Another discussion was at the Simulation Group extended meeting on the 2nd of March 2021 [12].

This work is foreseen to be done on an initial 2-year period with the possibility for extensions.

FTE assigned: 2.0
Duration: 2 years

3.3 Duration of the Association

The association as Technical Institute should last until the completion of the work packages described in section 3.2. The work packages have different durations from 2 to 5 years with the possible extensions in case of mutual interests. Therefore, GTU propose an initial membership for five years starting from 2022 to 2026 including.

GTU is open to wider cooperation with the ATLAS and will be attentive to additional requests.

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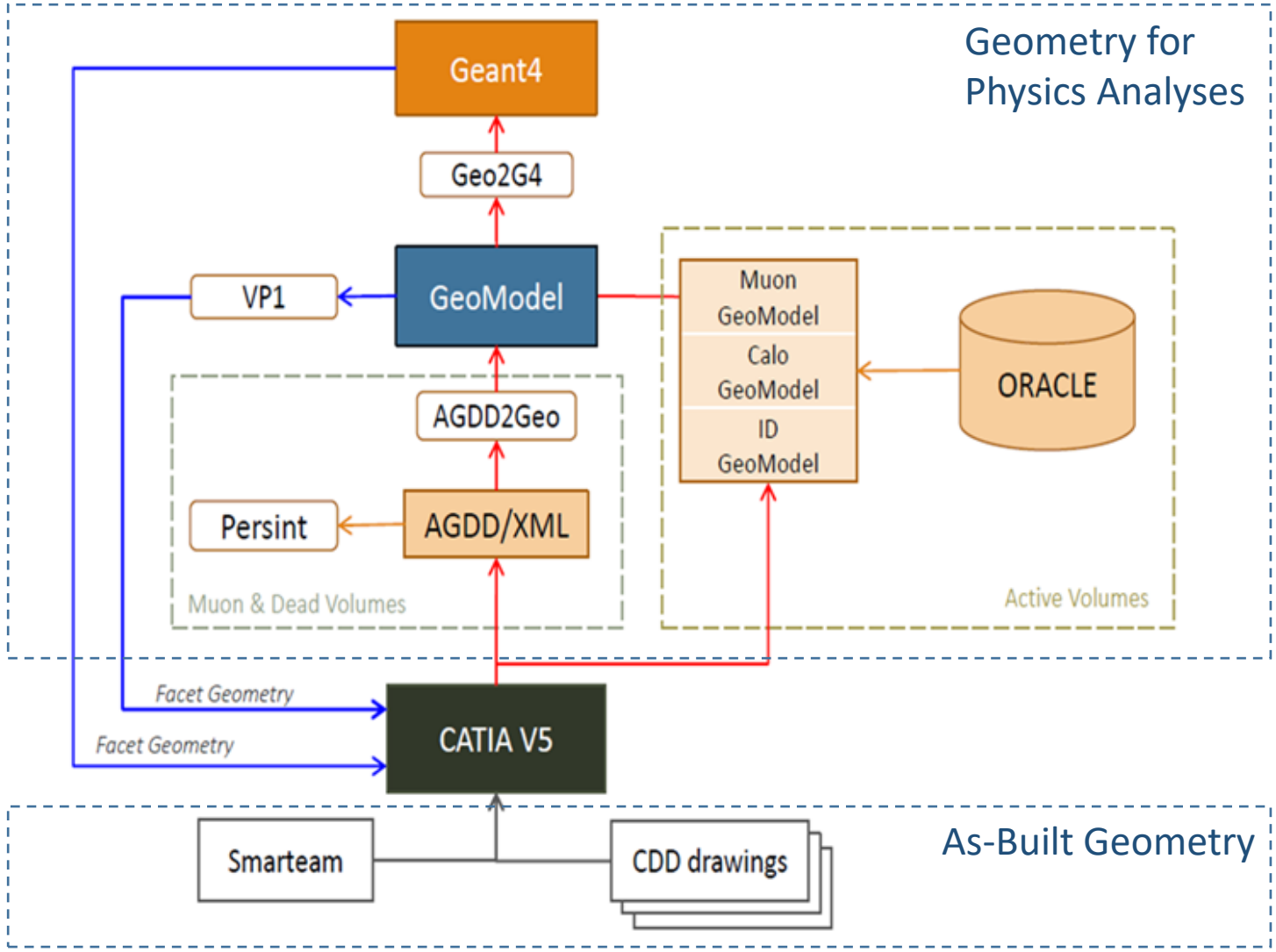
Simulation Loop with CATIA

- CATIA has been integrated in the existing simulation infrastructure of ATLAS



Special connectivity's was developed:

- CATIA-2-XML
- CATIA-2-GeoModel
- GeoModel-2-CATIA
- GEANT-2-CATIA

- Therefore, we are using CATIA as a hub to collect different geometry descriptions and compare them to the CAD engineering DB of CERN

Compare Analyses of Geometries for Simulation

CATIA Analyses include:

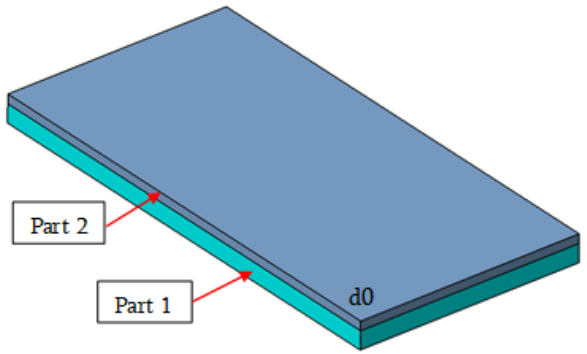
- Mass Analyses
- Radiation Analyses
- Conflicts Checking
- Positioning Checking
- Simplification of Geometry

- We are using DMU modules of CATIA and 3rd-party software applications developed by GTU
- We have successful experience working with ATLAS *Muon* group – 14 projects since 2010 and *Tile Calorimeter* group -7 projects since 2020

Methodology

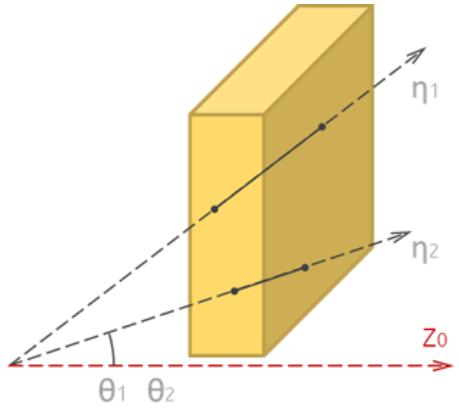
- Study of the Radiation on the early stage of geometry development in CATIA

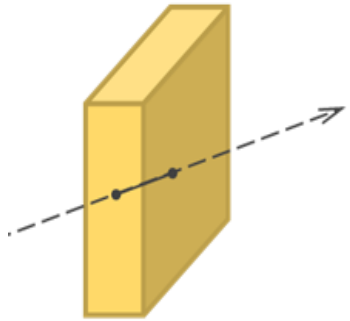
$$X_0 = \frac{716.4}{Z \times (Z+1) ln \frac{287}{\sqrt{Z}}} \; g.sm^{-3}$$

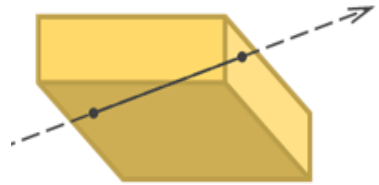


$$d_0\rho_0 = d_1\rho_1 + d_2\rho_2$$

θ	η	θ	η
0°	∞	180°	−∞
0.1°	7.04	179.9°	−7.04
0.5°	5.43	179.5°	−5.43
1°	4.74	179°	−4.74
2°	4.05	178°	−4.05
5°	3.13	175°	−3.13
10°	2.44	170°	−2.44
20°	1.74	160°	−1.74
30°	1.32	150°	−1.32
45°	0.88	135°	−0.88
60°	0.55	120°	−0.55
80°	0.175	100°	−0.175
90°	0		

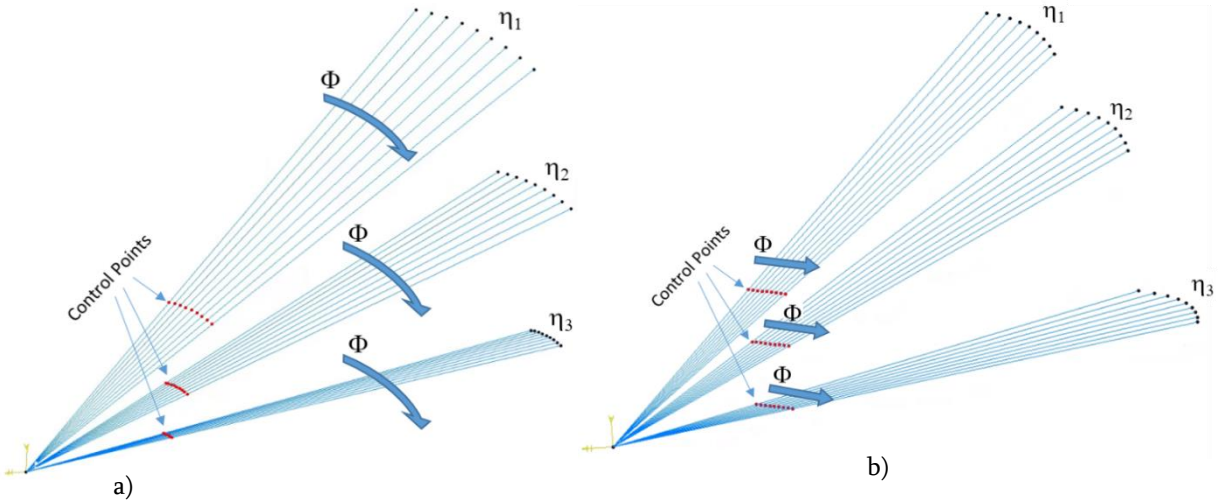






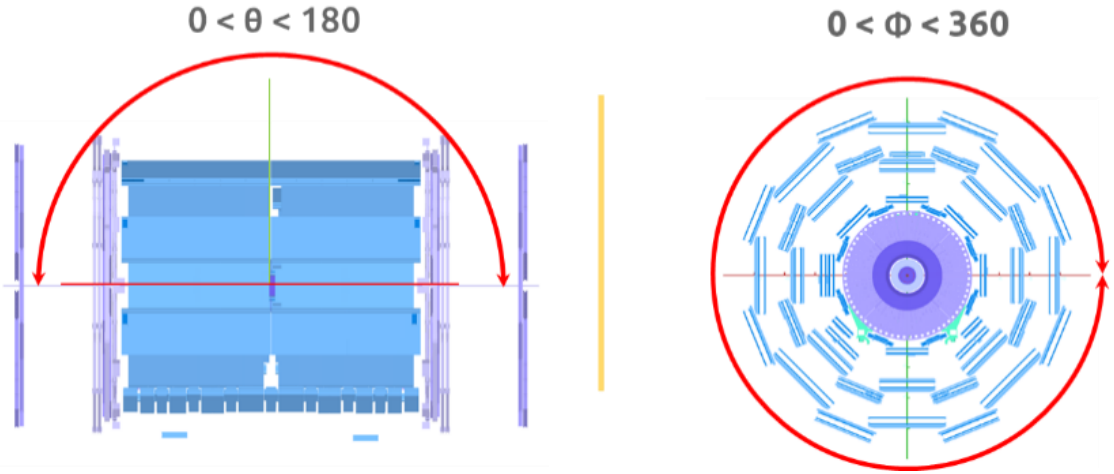
Methodology

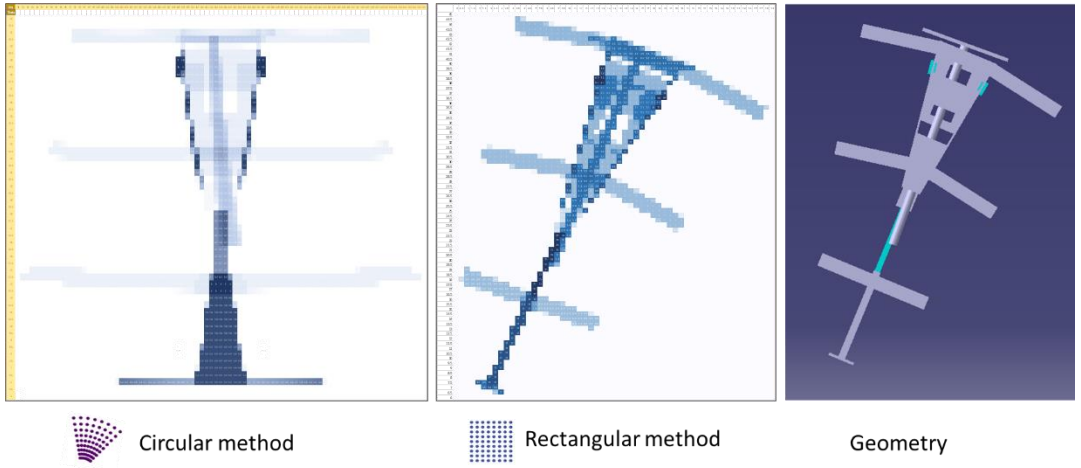
- Finding the Transition points



$$C = \forall_i (t_i \neq t_{i+1} \bigwedge \varphi_{(t_i)} = const \bigvee m_i \neq m_{i+1}$$

$$P_\Sigma = \sum_{i=1}^{n} \sum_{k=1}^{ij} P_{ik}(\Phi)$$

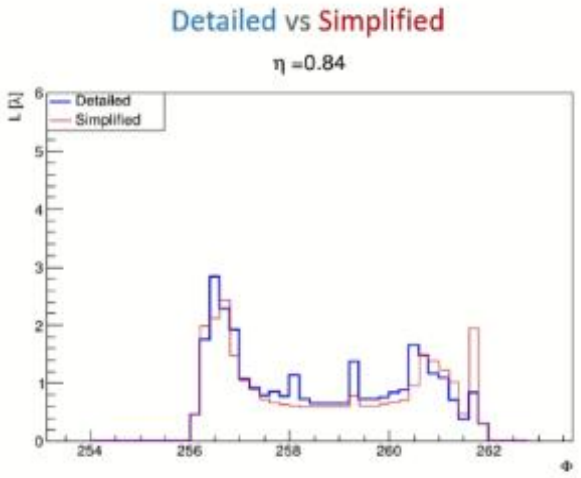


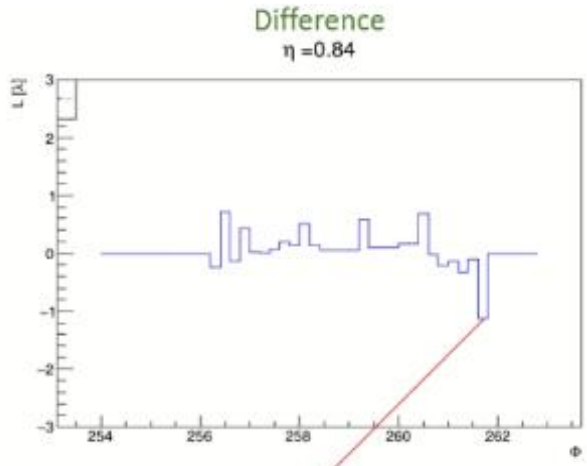


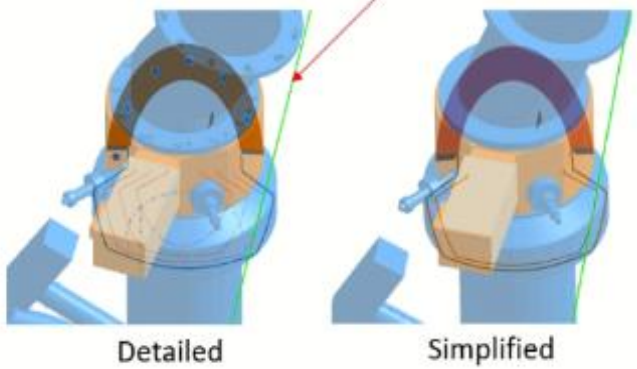
Simplification of Geometry

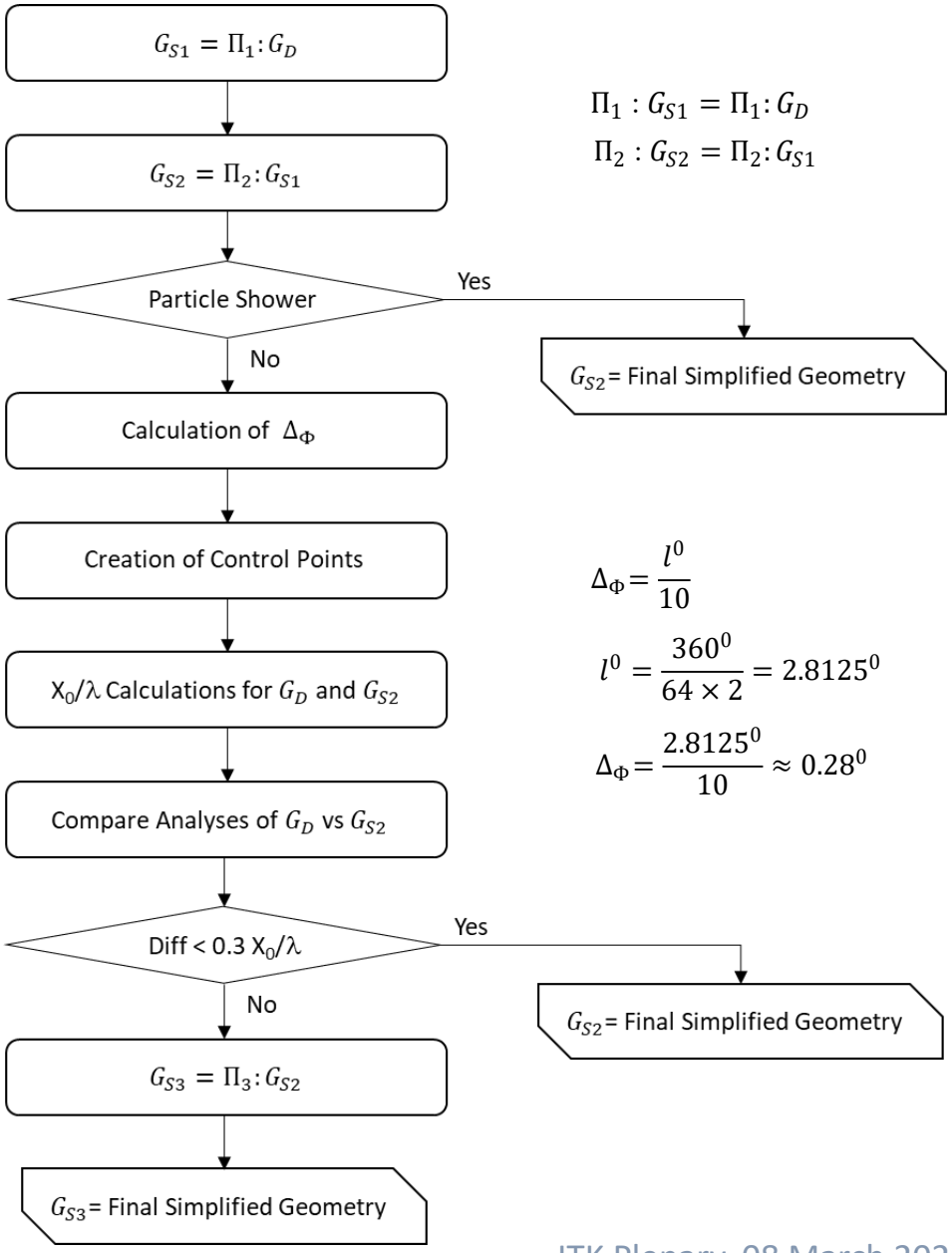
- Criteria of Simplification

$$C_{\Pi} = \forall\left(\left(M = const \bigwedge V = const\right) \bigvee (L_{Xo} = const \vee L_{\lambda} = const)\right)$$









$\Pi_1 : G_{S1} = \Pi_1 : G_D$

$\Pi_2 : G_{S2} = \Pi_2 : G_{S1}$

$$\Delta_\Phi = \frac{l^0}{10}$$

$$l^0 = \frac{360^0}{64 \times 2} = 2.8125^0$$

$$\Delta_\Phi = \frac{2.8125^0}{10} \approx 0.28^0$$

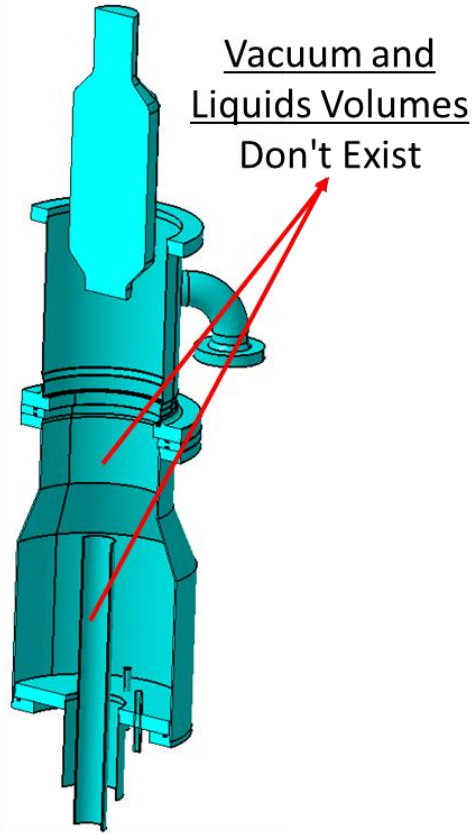
- Development of the Simulation Geometry in the CATIA

	Step	Output
1	Dump geometry from the SmarTeam	3D Model
2	Reproduction of the SmarTeam Geometry	3D Model; Technical Report
3	Dump Geometry from the GeoModel	3D Model
4	Compare analysis	Technical Report
5	Radiation Analyses - CATIA Detailed vs. GeoModel	Technical Report
6	Simplification of Geometry	3D Model; Technical Report
7	Radiation Analyses - CATIA Detailed vs. CATIA Simplified	Technical Report
8	Conflicts Checking	Technical Report
9	Modification of Geometry	3D Model
10	Preparation of AGDD/XML Description	XML file
11	Upload results on GitLab	Summary: 5 Models; 6 Technical reports; 1 XML file

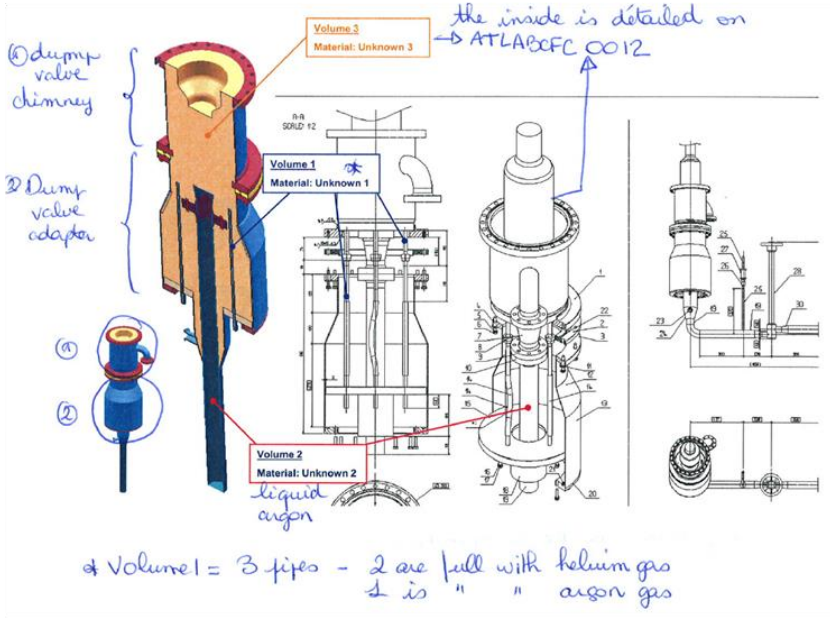
Case Study : LA Dump Valve Analyses

- Reproduction of the Geometry

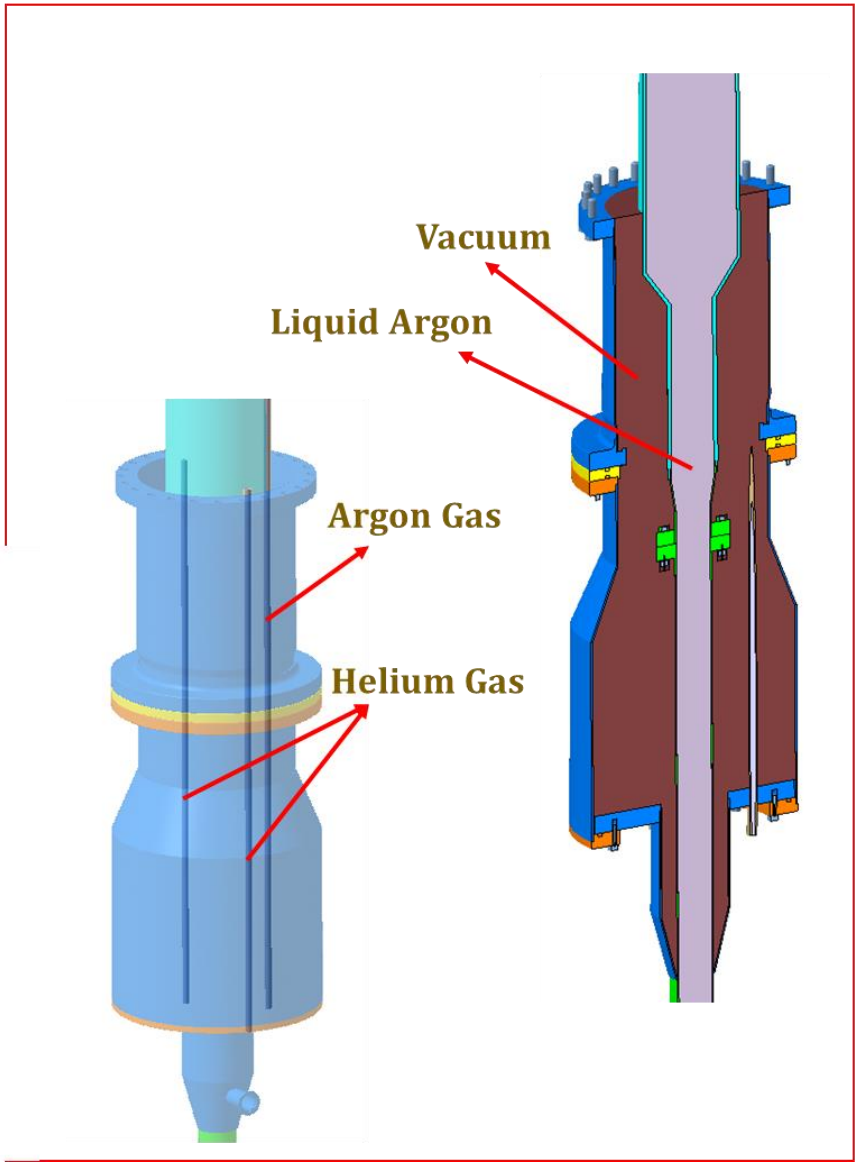
SmarTeam



Information from Caroline

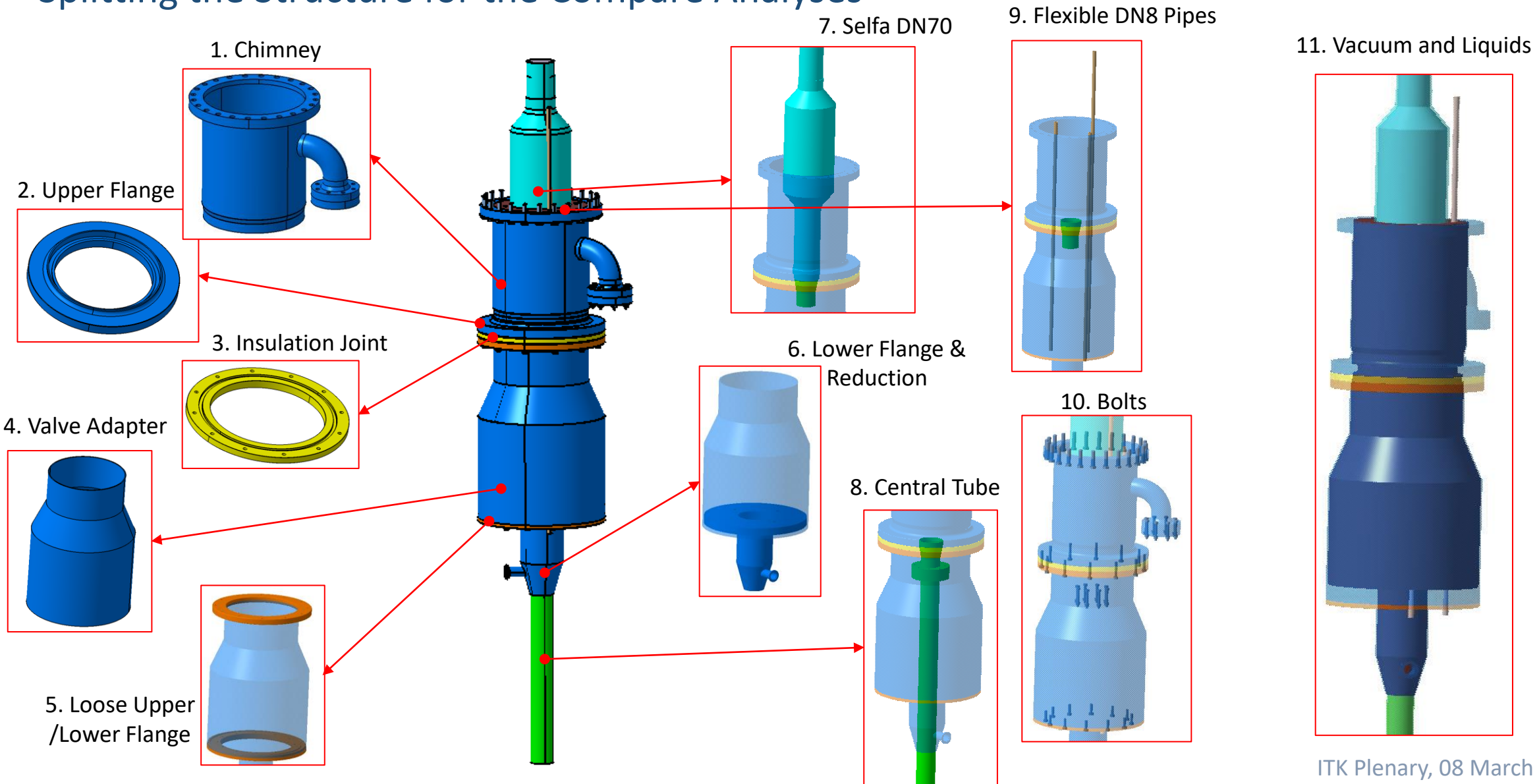


Geometry after the Reproduction



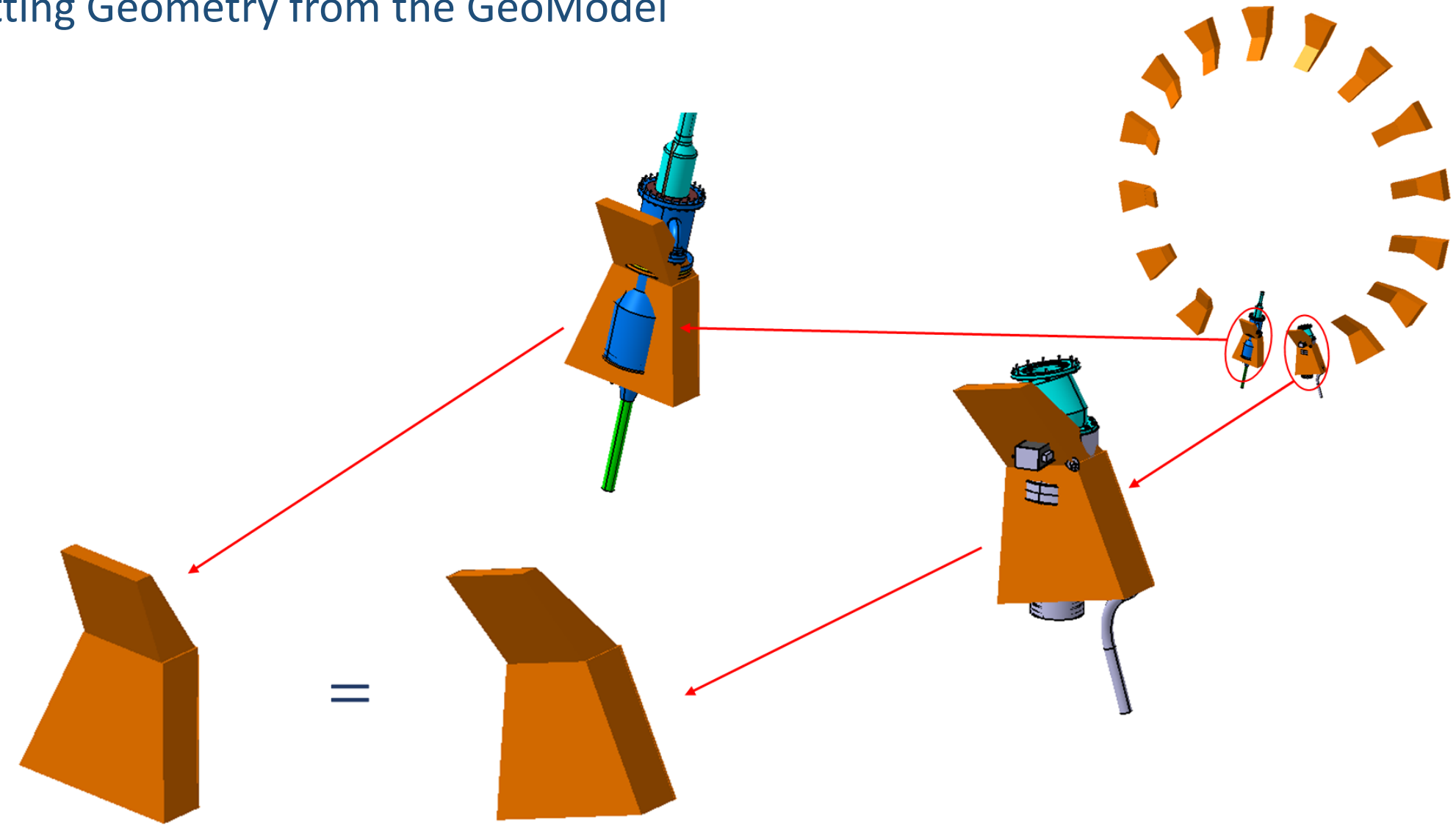
Case Study : LA Dump Valve Analyses

- Splitting the Structure for the Compare Analyses



Case Study : LA Dump Valve Analyses

- Getting Geometry from the GeoModel



Case Study : LA Dump Valve Analyses

- Compare Analyses of Mass Properties

As-Built

#	Name	material	Volume	Weight
1	Chimney	Stainless Steel	0.001587	12.5
2	Upper Flange	Stainless Steel	0.001257	9.9
3	Insulation Joint	Polycarbonate	0.000595	0.6
4	Valve Adapter	Stainless Steel	0.001417	11.2
5	Loose Upper/Lower Flange	Stainless Steel	0.001537	12.1
6	Lower Flange & Reduction	Stainless Steel	0.001966	15.5
7	Selfa DN70	Stainless Steel	0.00142	11.2
8	Central Tube	Stainless Steel	0.000759	6
9	Flexible DN8 Pipes	Stainless Steel	0.000179	1.4
10	Bolts	Stainless Steel	0.000327	2.6
11	Vacuum and Liquids	~~Vacuum~~ Liquid Argon ~~Argon Gas~~ ~~Helium Gas~~	~~0.04607~~ 0.010675 ~~0.000099~~ ~~0.00015~~	--- 14.9 ~~0.00016~~ ~~0.000025~~
		Total:	**0.022**	**98**

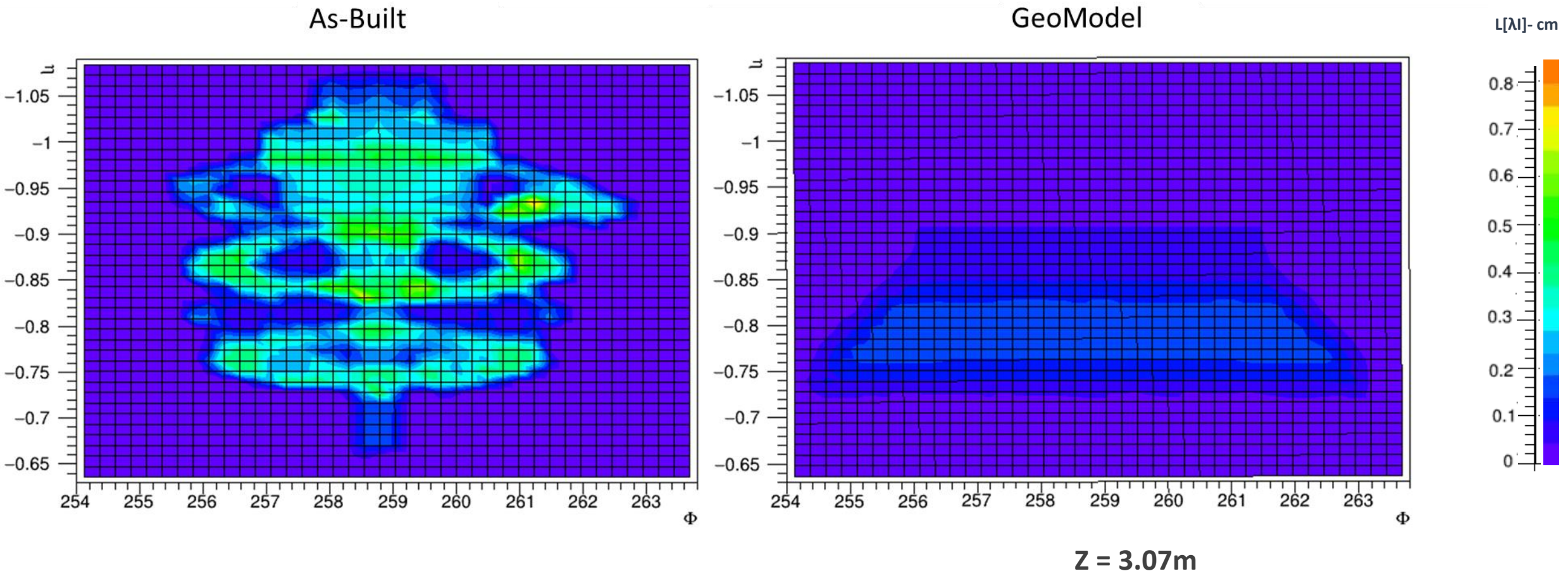
GeoModel

#	name	material	Volume (m3)	Mass (kg)
1	Base Envelope	LArServices8	0.067	23.5
2	Base Plate	Aluminum	0.0027	7.3
3	Bridge Envelope	LArServices8	0.0228	8
			Total:	40

Diff: -59 kg

Case Study : LA Dump Valve Analyses

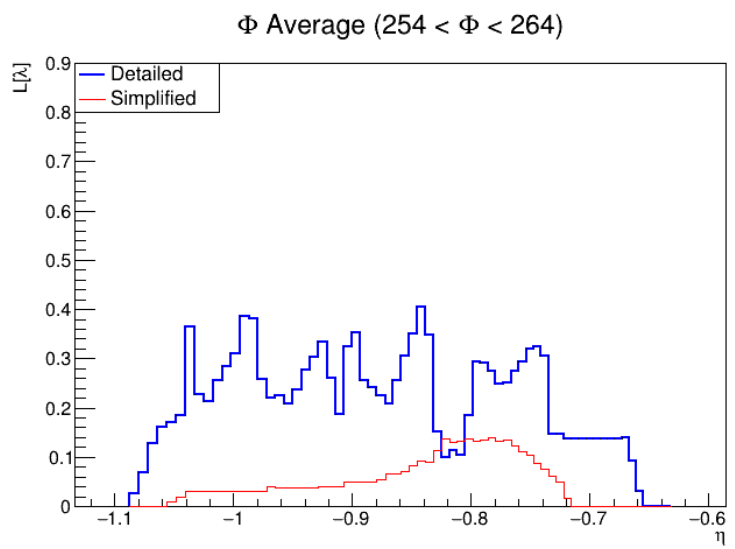
- Compare Analyses of Radiation Length

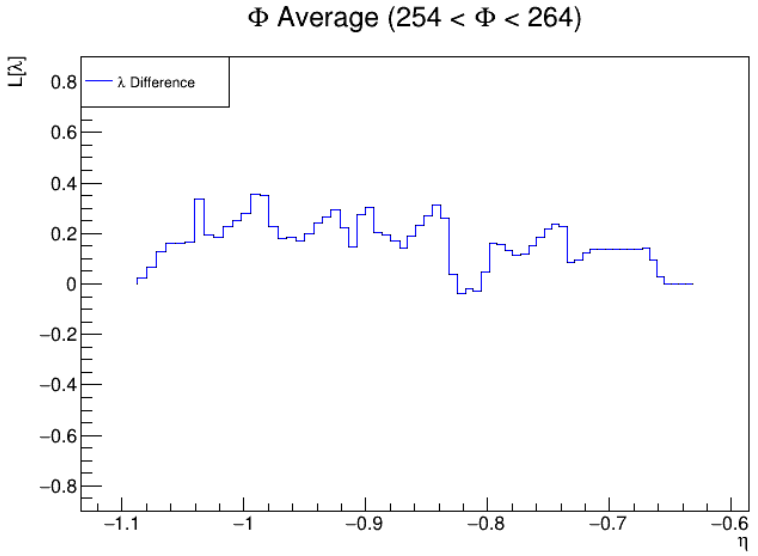


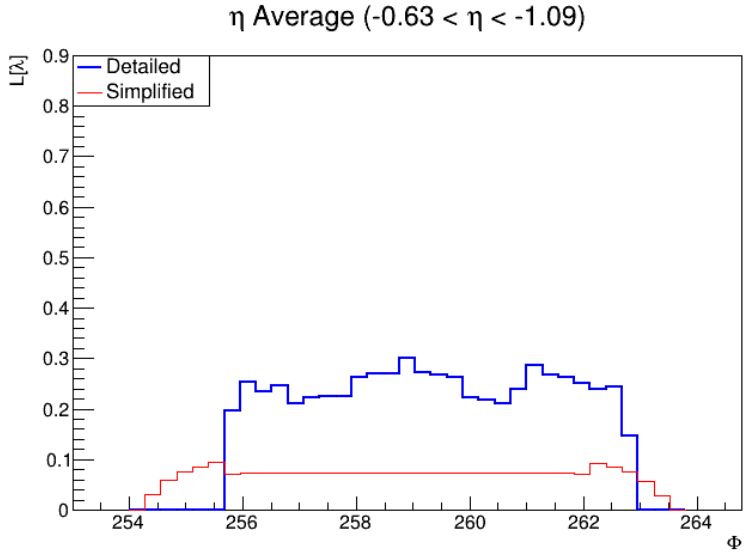
Z = 3.07m

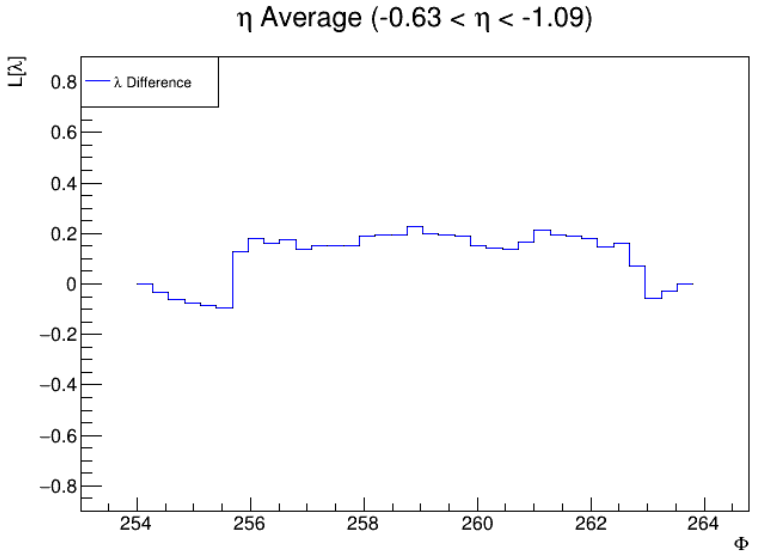
Case Study : LA Dump Valve Analyses

- Compare Analyses of Radiation Length



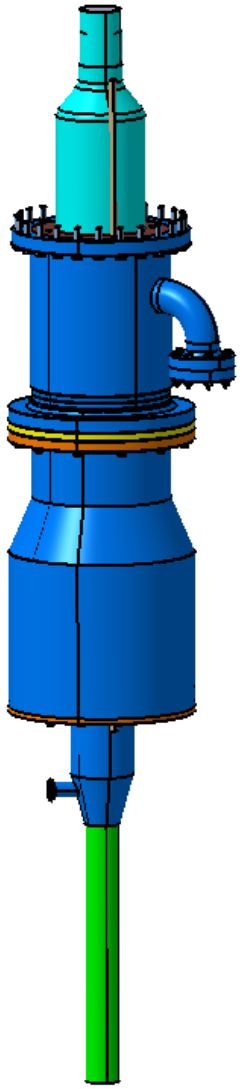






Case Study : LA Dump Valve Analyses

- Simplification of Geometry



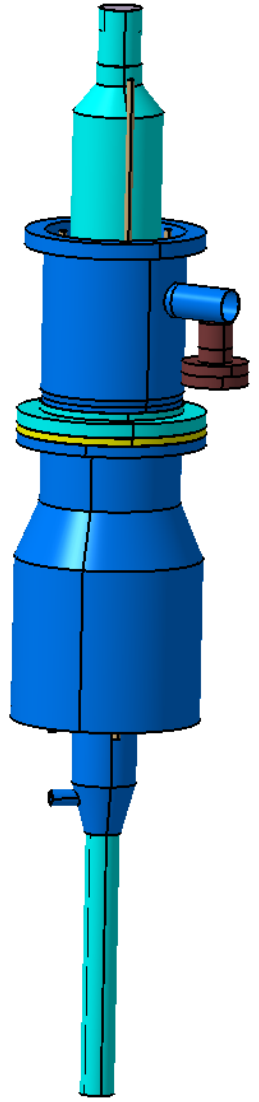
#	Name	Volume	Weight
1	Chimney	0.001587	12.5
2	Upper Flange	0.001257	10
3	Insulation Joint	0.000595	0.6
4	Valve Adapter	0.001417	11.2
5	Loose Upper/Lower Flange	0.001537	12.1
6	Lower Flange & Reduction	0.001966	15.5
7	Selfa DN70	0.00142	11.2
8	Central Tube	0.000759	6
9	Flexible DN8 Pipes	0.000179	1.4
10	Bolts	0.000327	2.6
11	Vacuum and Liquids	0.010675	15
	Total:	0.022	98

77 parts

Diff: 0

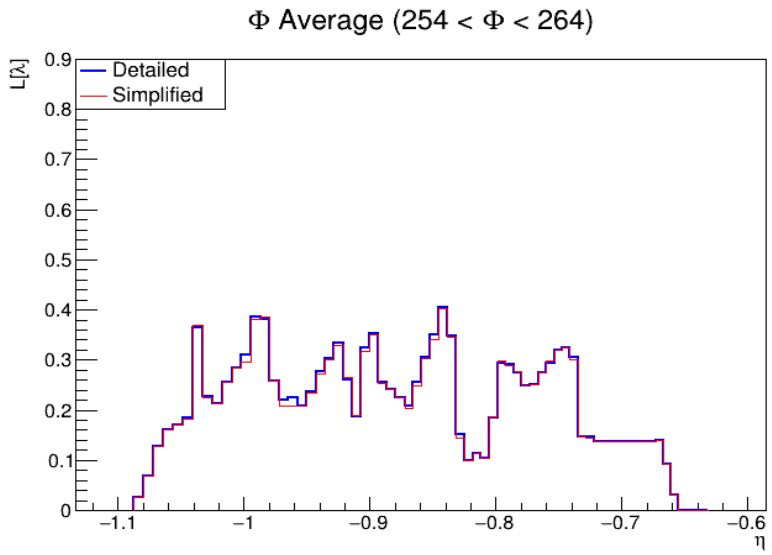
#	Name	Volume	Weight
1 2 10	Chimney Upper Flange Bolts	0.00306	24.1
3	Insulation Joint	0.000595	0.6
4 5 10	Valve Adapter Loose Upper/Lower Flange Bolts	0.003027	23.8
6	Lower Flange & Reduction	0.001966	15.5
7 8 10	Selfa DN70 Central Tube Bolts	0.002216	17.4
9	Flexible DN8 Pipes	0.000179	1.4
11	Volume of Liquid Argon	0.010675	14.9
	Total:	0.022	98

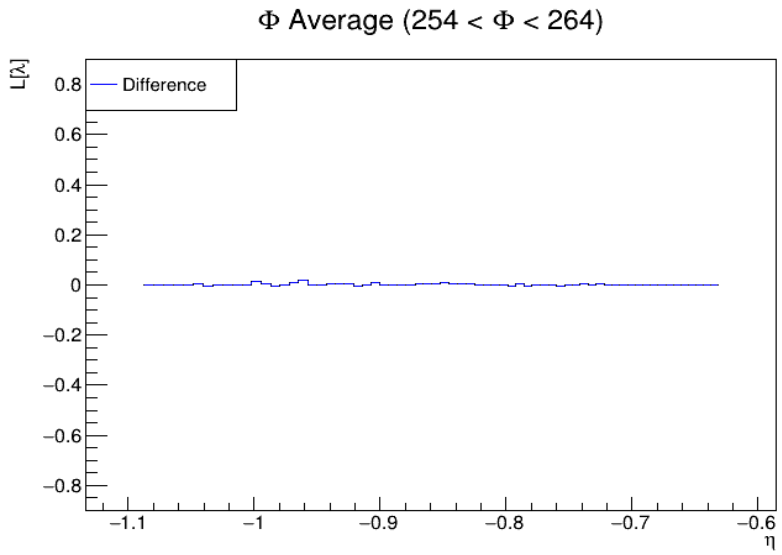
14 parts

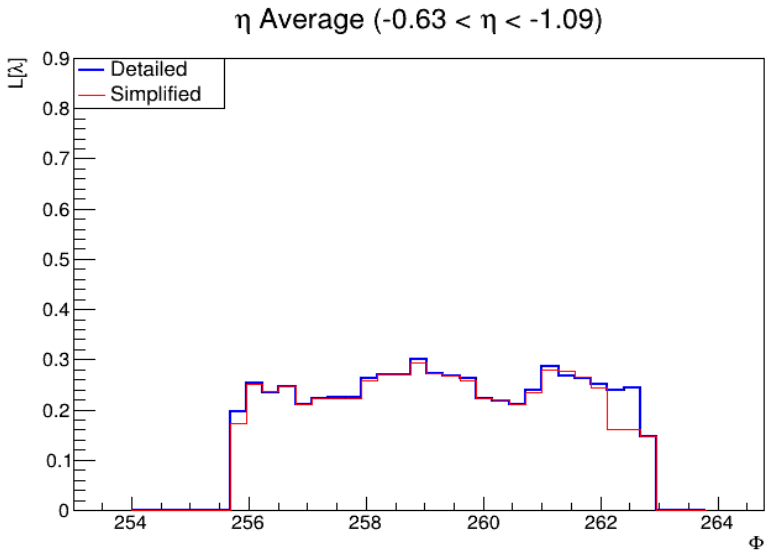


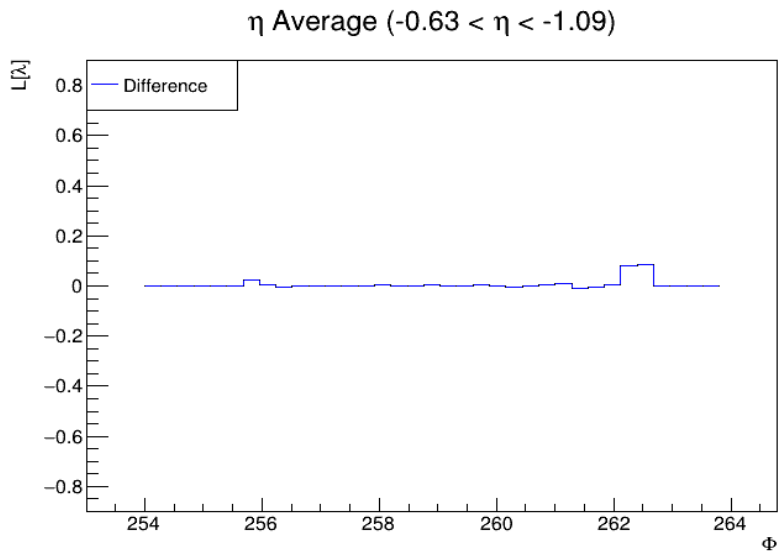
Case Study : LA Dump Valve Analyses

- Simplification of Geometry



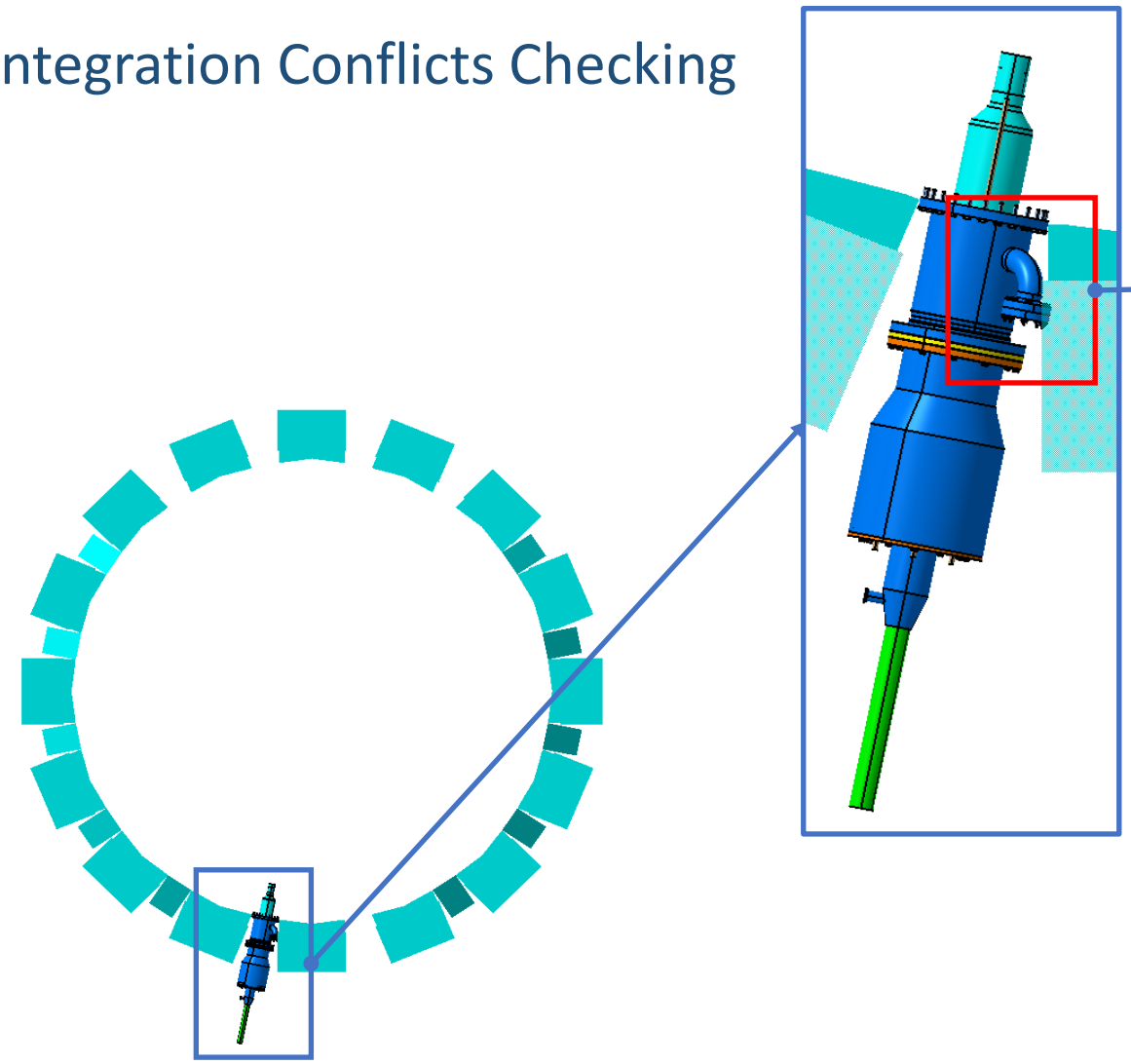


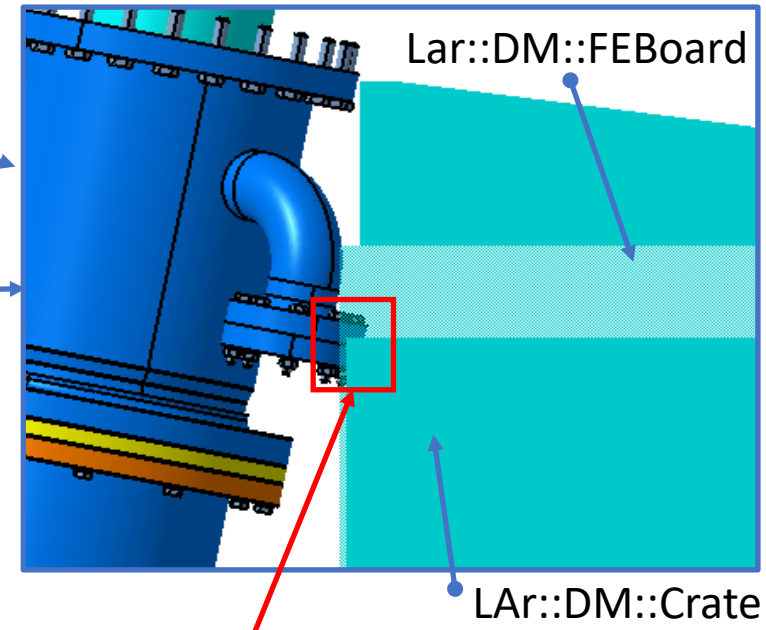


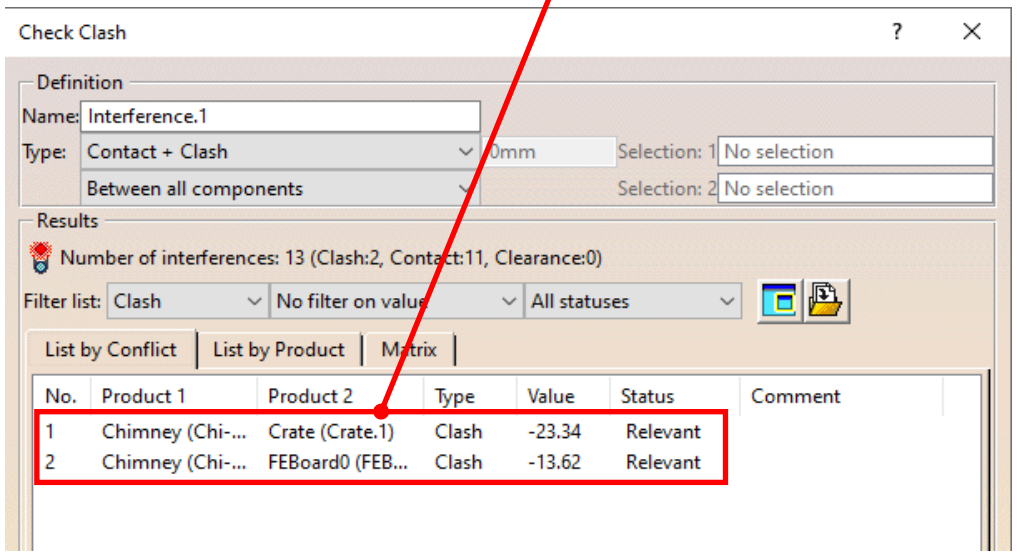


Case Study : LA Dump Valve Analyses

- Integration Conflicts Checking

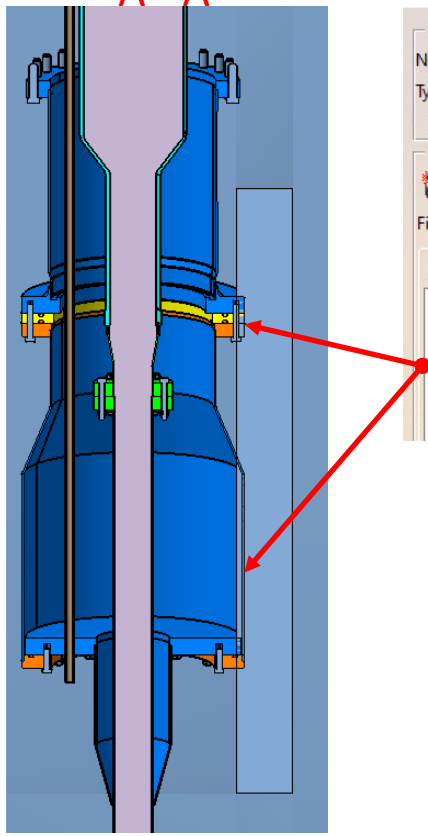






Case Study : LA Dump Valve Analyses

- Integration Conflicts Checking



Check Clash

Definition

Name: Interference.1

Type: Contact + Clash | 0mm | Selection: 1

Between two selections | Selection: 2

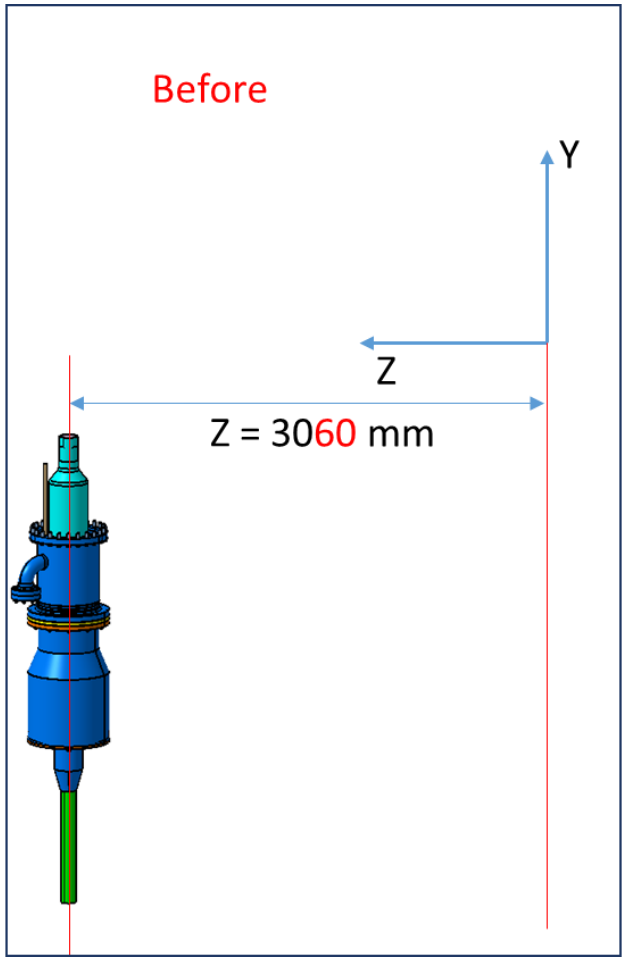
Results

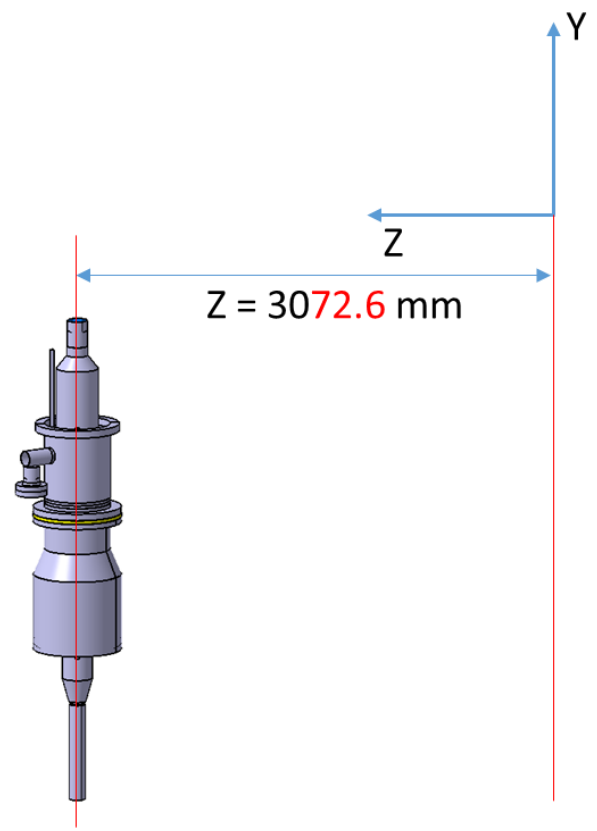
Number of interferences: 4 (Clash:4, Contact:0, Clearance:0)

Filter list: All types | No filter on value | All statuses

List by Conflict | List by Product | Matrix

No.	Product 1	Product 2	Type	Value	Status
1	TileCentralBarr...	Upper Flange (...	Clash	-12.25	Relevant
2	TileCentralBarr...	Loose Upper/L...	Clash	-12.25	Relevant
3	TileCentralBarr...	Valve Adapter, ...	Clash	-12.25	Relevant
4	TileCentralBarr...	Insulation Join...	Clash	-12.25	Relevant





Case Study : LA Dump Valve Analyses

- XML Coding

```
<composition  name="LAr_Baffle" >
   <posXYZ  volume="Baf_Outer" X_Y_Z=" 0. ; 0.; 0." rot=" 0.; 0. ; 0." />
   <posXYZ  volume="Baf_Top" X_Y_Z=" 0. ; 0.; 95.01" rot=" 0.; 0. ; 0." />
   <posXYZ  volume="Baf_Bot" X_Y_Z=" 0. ; 0.; -95.01" rot=" 0.; 0. ; 0." />
   <posXYZ  volume="Baf_Inner" X_Y_Z=" 0. ; 0.; 0." rot=" 0.; 0. ; 0." />
   <posXYZ  volume="Baff_ConnPl" X_Y_Z=" 0. ; 0.; 93.2" rot=" 0.; 0. ; 0." />
</composition>
<!-- End Baffle -->

<!-- Diffusion Pump -->
<tubs name="Diff_MainTube" material="SSteel" Rio_Z="106.5; 109.5; 455." nbPhi="36"/>
<tubs name="Diff_TopTube" material="SSteel" Rio_Z="107.; 118.25; 5." nbPhi="36"/>
<tubs name="Diff_BotTube" material="SSteel" Rio_Z="0.; 106.49; 5." nbPhi="36"/>

<tubs name="Diff_MainTubeCut" material="SSteel" Rio_Z="0.; 21.; 227.4" nbPhi="20"/>
<subtraction name="Diff_MainSbtr" >
   <posXYZ volume="Diff_MainTube" />
   <posXYZ volume="Diff_MainTubeCut" X_Y_Z=" 181.44; 0.; -31.55" rot=" 0.; 60.; 0." />
</subtraction>

<tubs name="Diff_SideTubePos" material="SSteel" Rio_Z="21.; 24.; 227.22" nbPhi="20"/>
<tubs name="Diff_SideTubePosCut" material="SSteel" Rio_Z="0.; 109.53; 80." nbPhi="20"/>
<subtraction name="Diff_SideTube" >
   <posXYZ volume="Diff_SideTubePos" X_Y_Z=" 181.44; 0.; -31.55" rot=" 0.; 60.; 0."/>
   <posXYZ volume="Diff_SideTubePosCut" X_Y_Z=" 0.; 0.; -80." rot=" 0.; 0.; 0."/>
</subtraction>

<union name="LAr_Diffusion_PumpUn" >
   <posXYZ volume="Diff_MainSbtr" X_Y_Z=" 0.; 0.; 0." rot=" 0.; 0.;0."/>
   <posXYZ volume="Diff_TopTube" X_Y_Z=" 0.; 0.; 225." rot=" 0.; 0.;0."/>
</union>

<composition  name="LAr_Diffusion_Pump_Outer" >
   <posXYZ  volume="LAr_Diffusion_PumpUn" X_Y_Z=" 0. ; 0.; 0." rot=" 0.; 0. ; 0." />
   <posXYZ volume="Diff_BotTube" X_Y_Z=" 0.; 0.; -225." rot=" 0.; 0.;0."/>
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</composition>
```

256 Programing strings

Case Study : LA Dump Valve Analyses

Project overall parameters	
Started	2 April, 2021
Involved manpower	2FTE
Number of task executed	17
Working days spent	39

Conclusions

1. Using CATIA enables to bring as-built geometry descriptions for the Simulation
2. It is possible to investigate current GeoModel/XML descriptions for consistency to the as-built descriptions
3. The radiation analyses in CATIA brings the opportunity to deliver on the early stage of Geometry development accurate geometries for the simulation
4. Past 14 projects for the Muon system and 7 projects for the Tile Calorimeter system of Compare analyses showed big differences between GeoModel/XML descriptions and as-built descriptions
5. We are ready to bring our knowledge and expertise in order to deliver accurate and efficient geometries for the ITK

Thanks for the Attention!

მადლობთ ყურადღებისათვის!

Questions & Discussion